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HEAVY ION PHYSICS

High Transverse Momentum Ξ Baryon Correlations in p+p Collisions at $\sqrt{s} = 200\ GeV$.

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Abstract. Angular correlations between produced high p_T Ξ^- baryons and unidentified charged and neutral particles are observed in high-tower-triggered (on a large electromagnetic energy deposit) $\sqrt{s} = 200$ GeV p+p collisions. This trigger favors events with higher average multiplicity than those in minimum bias. These events are likely to contain jets. The average multiplicity of a high-tower triggered event is similar to that of a minimum bias event containing a Ξ baryon, which implies that Ξ baryons are likely to be produced in jets. Ξ^- $\langle p_T \rangle$ is higher in the triggered data then in the minimum bias sample.

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1. Introduction

STAR has measured high-p_T charged hadron suppression in the most central Au+Au collisions via unidentified azimuthal correlations [1] and the corresponding nuclear modification factors [2]. Jet reconstruction can be difficult in a high-multiplicity Au+Au collision environment, therefore two-particle correlations are employed to study jets statistically. As $p + p$ collisions are used as a reference for a Au+Au jet measurement, the statistical method is applied to $p + p$ collisions as well.

Identified strange high p_T correlations are another step towards furthering our understanding of the matter produced at RHIC, since strange particles are created in all collision systems. Moreover, strange particles provide a convenient comparison of produced quark ($\bar{s}s$) content vs. particle mass. They are also a tool in understanding the baryon/meson differences, especially useful because particle identification out to high p_T is possible. Thus strange particle correlations may yield new insights into the strangeness production mechanism in both p+p and Au+Au collisions.

2. Detectors and Data

2.1. Detectors

The 2π azimuthal coverage of the STAR detector makes it well-suited to study identified high-p_T two-particle correlations. The strange particles are reconstructed topologically via their decay products in the STAR Time Projection Chamber (TPC) [3], and correlated with charged tracks, likewise reconstructed using the TPC [4]. We also construct correlations between Ξ candidates and energy deposits in the STAR Barrel Electromagnetic Calorimeter (EMC), which are a result of electromagnetic showers from both charged particles and photons (either direct or π^0 daughters). In this analysis the EMC covers 2π in azimuth and 1 unit of positive pseudorapidity. It consists of three detectors: high energy towers (each having dimensions of $\Delta\eta = \Delta\phi = 0.05$) and two layers of shower-max detectors, SMD-ϕ and SMD-η. Using energy clusters from all three, an EMC point is reconstructed, which can then be used in correlation analyses.

2.2. Data

Although STAR recorded a 14 M minimum bias (min. bias) event sample in 2002, less than a thousand Ξ^- and $\overline{\Xi}^+$ candidates with $p_T > 2$ GeV/c were reconstructed [4]. To gain in statistics, we examine the 2 M events of the 2004 data triggered on a large localized deposit of energy in the STAR EMC. The events in this triggered data sample consist events triggered on a minimum 2.5 GeV deposited in one EMC tower. Assuming that in a $p + p$ collision high energy particles are more likely to be created via parton fragmentation, this trigger selects data with more jets than in a min. bias sample. The increase in jettiness appears to correlate to increased mean multiplicity of the events [5]. When an event is triggered by a deposit above threshold in one of the towers, data from other towers are also recorded.

3. Analysis and Results

By using triggered data, we increase the probability of producing high p_T Ξ baryons suitable for correlations, as seen in Fig.1. There we see raw Ξ^- spectra normalized to number of events in the respective data set. There are more Ξ^- baryons produced in the triggered data than in the min. bias for $p_T > 2$ GeV/c, thus increasing the $\langle p_T \rangle$ of the Ξ^- spectrum. Therefore, triggering introduces a bias. To understand this bias, we examine the difference between all min. bias events and those min. bias events where we reconstruct a Ξ baryon. We also compare multiplicity distributions of the two data sets. In the min. bias sample, as the multiplicity of the $p+p$ collision increases, the $\langle p_T \rangle$ of produced particles has been observed to rise [6]. Fig.2 shows the difference in uncorrected charged primary track distributions between min. bias and high tower triggered events for $|y| < 0.75$. The mean of the former is 5.86 ± 0.01 charged tracks, while the mean of the latter is 11.94 ± 0.01. When only min. bias

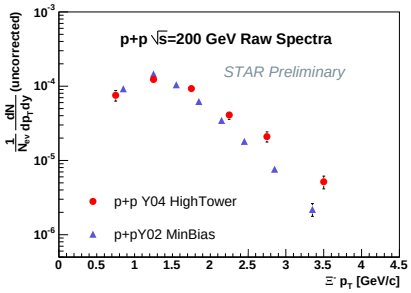

Fig. 1. Uncorrected Ξ^- spectra in minimum bias (triangles) and high tower (circles) events from $\sqrt{s} = 200$ GeV $p+p$ collisions.

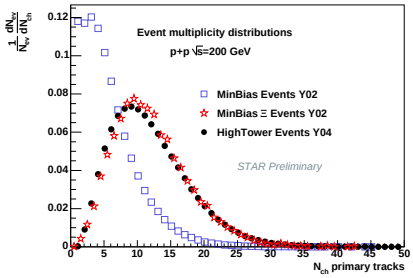

Fig. 2. Multiplicity distributions in all $\sqrt{s} = 200$ GeV $p+p$ minimum bias events (squares), minimum bias events with a Ξ^- baryon (stars) and all triggered events (circles).

events with a Ξ baryon are selected, the mean of the multiplicity distribution rises to 12.12 ± 0.05. Thus events where a Ξ baryon is produced belong to the same multiplicity class as high-tower triggered events. Since the enhanced multiplicity of the event might correspond to a higher event $\langle p_T \rangle$ and thus to increased jettiness [5], we conclude that Ξ baryons are likely to be produced in jets.

Further evidence of a jet would be given by a same-side and a back-to-back correlation between a Ξ and the other particles in the event. In order to construct such a correlation, a Ξ^- with $p_T > 2$ GeV/c is used as a trigger particle, while its partner is either a charged track ($h^\pm$ with $p_T > 1.5$ GeV/c) reconstructed in the TPC, or a charged or neutral particle detected using an energy deposit in the EMC (the default cluster-finder energy cut-off of 700 MeV was used). Then a correlation function is constructed:

$$C(\Delta\phi) = A_0 e^{-\frac{\Delta\phi}{2\sigma_0^2}} + A_\pi e^{-\frac{(\Delta\phi-\pi)}{2\sigma_\pi^2}} + B$$

where A_0 and A_π are amplitudes of two Gaussian distributions of width σ_0 and σ_π respectively, centered at 0 and π radians. In $p+p$ collisions the Gaussians are assumed to sit on a flat background of height B. $\Delta\phi$ is calculated by measuring the relative angle between the trigger particle and an associated particle: a charged or a neutral hadron. Tracks and points that are due to Ξ decay products are excluded from the correlations. To improve the statistics, after a raw correlation is obtained the data is folded around maxima at 0 and π radians. The folding is possible due to the expected symmetry of the away- and the same- side peaks.

While in the min. bias data set the statistics are poor [4], we see correlation functions for both $\Xi^- - h^\pm$ (Fig.3) and Ξ-EMC points (Fig.4) in the high-energy triggered data. The cut-off for an EMC point is set at 700 MeV. Due to this low cut-off energy, the Ξ-EMC point correlation function sits on a higher soft-particle correlation background. The rapidity range for $h^\pm$ is $|y| < 0.75$, whereas it is $0 < y < 1$ for the EMC points. Because the tower points are not identified at this stage of analysis, and the geometry as well as efficiency of the correlations differ, a

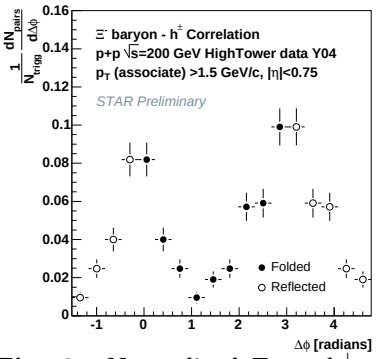

Fig. 3. Normalized $\Xi^- - h^{\pm}$ correlations in triggered $\sqrt{s}$ = 200 GeV p+p data. The points have been folded around 0 and π radians.

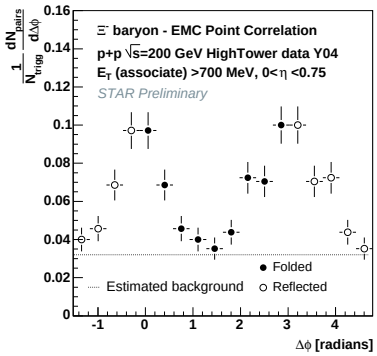

Fig. 4. Normalized Ξ^--EMC Point correlations in triggered $\sqrt{s}$ = 200 GeV $p+p$ data. The points have been folded around 0 and π radians.

direct comparison between Ξ-EMC point correlation yields and $\Xi - h^{\pm}$ yields cannot yet be made.

4. Conclusions

Angular correlations between produced high p_T Ξ^- baryons and unidentified charged and neutral particles (EMC points) are seen in the high-tower triggered $p+p$ collisions. We see unambiguous same-side and away-side peaks for both types of correlations. The high tower trigger seems to favor events with higher than average multiplicity, and thus selects events where a Ξ^- is more likely to be produced than in the min. bias collisions.

Further comparison of high tower data to the min. bias sample is needed before the results can be compared to those in Au+Au collisions, or corrected yields calculated. Once the bias is determined, correlation widths and yields will allow characterization of jets in which Ξ^- candidates appear to be produced. These yields and widths will then be compared to those in the Au+Au data set. 70M Au+Au min. bias event are currently being reconstructed for analysis. Ξ correlation yields in comparison to Λ^0 and K^0_s yields should be insightful in $p+p$ as well as in Au+Au collisions.

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